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Maternity roost site selection of big brown bats in ponderosa pine forests of the Channeled Scablands of northeastern Washington State, USA

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Abstract

Bats play a variety of ecological roles in forest ecosystems and forest management can impact habitat conditions for forest-dwelling bats. We examined the use and characteristics of roosts selected by reproductive female big brown bats (*Eptesicus fuscus*) in the Channeled Scablands of northeastern Washington. We radio-tracked 14 bats to locate 36 roosts. Bats were found in colonies averaging 27 and these colonies switched roosts about every 3.7 days. Habitat variables were measured for the roost itself and at a 0.1-ha microplot and 78-ha macroplot surrounding each roost. We measured habitat variables at random 0.1-ha microplots in the vicinity of each roost and at general random 0.1-ha microplots and 78-ha macroplots. Of the 36 roosts located, 34 were in natural tree cavities; 28 were in ponderosa pine (*Pinus ponderosa*) and eight in quaking aspen (*Populus tremuloides*). Dead tops of live pine trees were used significantly more as roosts than pine snags. Although there were significantly more roosts in trees >30 cm in diameter and >12 m high than what was available, roosts were not always the tallest tree in the stand. A significantly greater proportion of big brown bat roosts were found in open pine, aspen and mixed-aspen pine forests and less in grasslands and closed pine than expected. Forest management strategies should protect both large diameter snags and existing dead top live trees and maintain natural population levels of biological agents that create dead tops. Restoration of historic open conditions in ponderosa pine and aspen stands will provide improved habitat for big brown bats.
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Keywords: Big brown bat; *Eptesicus fuscus*; Dead top live trees; Maternity roosts; Ponderosa pine; Quaking aspen; Porcupine; Snags

1. Introduction

Bats play a variety of ecological roles in forest ecosystems (Marcot, 1996) and by altering habitat conditions, different forest management approaches have the potential to impact the abundance and distribution of forest-dwelling bats (O'Connell and Hallett, 2000). Maternity roost sites are an important resource for bats and their availability can be a major determinant of population size and distribution in temperate latitudes (Kunz, 1982). Roost selection is mediated by factors that vary regionally reflecting differences in availability, climate, potential predators, thermoregulatory requirements, and proximity to foraging habitat and water (Barbour and Davis, 1969; Brigham, 1991; Nagorsen and Brigham, 1993; Barclay and Brigham, 1996; Campbell et al., 1996; Chruszcz and Barclay, 2002; Rancourt et al., 2005). Therefore, examining factors determining roost selection throughout a species' geographic distribution is important for understanding the potential impact of forest management on forest-dwelling bats.

Big brown bats (*Eptesicus fuscus*) are distributed throughout North and Central America. While known to use a variety of natural and human-made roost types, big brown bats exhibit site-specific selection of roosts in different locations. Big brown bat maternity colonies were found exclusively in ponderosa pine (*Pinus ponderosa*) snags in northern Arizona (Rabe et al., 1998), in yellow-bellied sapsucker cavities in live and dead aspen in southwestern Saskatchewan (Kalcounis and Brigham, 1998), in rock crevices in southeastern Alberta (Lausen and Barclay, 2003), and in human-made structures in Ontario (Brigham, 1991). Although big brown maternity colonies are often found in buildings (Showalter and Gunson, 1979;

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Brigham and Fenton, 1986; Cope et al., 1991; Williams and Brittingham, 1997), Brigham (1991) found colonies only in ponderosa pine snags in south-central British Columbia, despite the availability of buildings. In contrast, Lausen and Barclay (2006) concluded that female big brown bats gain certain benefits with respect to predation risks, juvenile growth rates, and energy savings by selecting maternity roosts in buildings over rocks. These observations support Brigham's (1991) suggestion that additional studies of roost-site selection of reproductive big brown bats were necessary to determine if their use of buildings is a result of loss of natural roosting habitat.

Moreover, similar to many other species of bats (e.g., Lewis, 1995; Sherwin et al., 2000; Kunz and Lumdsen, 2003), individual big brown bats are known to switch roost sites periodically (e.g., Rabe et al., 1998; Willis and Brigham, 2004). As Barclay and Brigham (2001) noted, frequent roost-switching behavior means that conservation of roosting habitat must be on a larger scale than an individual roost site.

We examined maternity roost selection of the big brown bat in the Channeled Scablands of eastern Washington. The Scablands area with its stands of ponderosa pine and quaking aspen (*Populus tremuloides*) forests intermixed with basalt rock outcrops and cliffs, numerous wetlands, shrub-steppe, and human habitation provides the full spectrum of roost and foraging sites. This juxtaposition of potential roosting and foraging habitat provides an opportunity to investigate the basis for selection of specific roost types and sites. Specifically, our objectives were to identify the types of roosts selected by reproductive female big brown bats, examine patterns of use, and determine site and habitat characteristics of these roosts.

2. Methods

2.1. Study area

Our research was conducted on Turnbull National Wildlife Refuge (TNWR) in northeastern Washington State. The 6307 ha refuge is located amidst the Channeled Scablands on the eastern edge of the Columbia Basin Plateau. Elevations range from 670 to 720 m. A modified maritime climate of warm, dry summers ($\bar{x} = 27\,^{\circ}C$) and cool moist winters (-4 to $-1\,^{\circ}C$) is typical of the region. Topographic variations across TNWR result in a 10–15 °C difference among microclimatic pockets. Average annual precipitation is 42 cm, occurring primarily as rain or snow in winter and early spring (National Oceanic and Atmospheric Association, 1997).

Numerous wetlands comprised of vernal pools, pothole basins, and larger permanent ponds constitute 20% of the landscape (USFWS, 1999). The 130 wetland basins within the refuge were formed by volcanic activity and several massive floods that occurred at the end of the Pleistocene Epoch (Allen et al., 1986). Two important ecological zones make up TNWR, a Ponderosa Pine Zone and a remnant of the Palouse Zone. Second-growth pine forests cover approximately 40% of TNWR and are represented by two plant associations. Ponderosa pine–Idaho fescue (*Festuca idahoensis*) association is found on shallower, drier soil with a more open canopy and ponderosa pine–snowberry (*Symphoricarpos albus*) association typically occurs in topographic depressions and near wetlands (Daubenmire, 1952). The 2307 ha of Palouse habitat on TNWR is dominated by meadow and shrub-steppe plant communities within a landscape consisting of shallow rocky soils interspersed with regularly occurring soil mounds (Daubenmire, 1970). Edges of wetland basins, channels, and meadows, that constitute <2% of TNWR, are dominated by quaking aspen with an understory of red-osier dogwood (*Cornus stolonifera*), thinleaf alder (*Alnus tenuifolia*), water birch (*Betula occidentalis*), black hawthorne (*Crataegus douglasii*), and snowberry.

2.2. Bat capture and telemetry

We trapped bats at 17 harp trap (constructed following Tidemann and Woodside (1978) and 50 mist net (Avinet Inc., Dryden, New York, USA) sites at different wetland, road, and forest areas distributed throughout TNWR from June through September of 1996 and 1997. We identified all bats to species, and recorded their sex, age, and reproductive condition (Anthony, 1988; Racey, 1988).

Radiotransmitters (LB-2, Holohil Systems Ltd., Carp, Ontario, Canada) weighing approximately 0.45–0.51 g were attached to 14 pregnant or lactating big brown bats. Following a 1-day waiting period, a 3-element Yagi antenna and a TRX-2000S (Wildlife Materials Inc., Carbondale, Illinois, USA) receiver were used to locate radio-marked bats at day roosts. Bats were located daily until the transmitter terminated (10–21 days). Individual roost sites were revisited at night, using night vision equipment to reduce potential disturbance, to determine specific location of the roost, verify its status as a maternity colony, and record emergence time and number of individuals in the colony. If a radio-tagged bat switched roosts, we revisited the old roost site for three consecutive nights to verify that no bats left the old roost. We visited the new roost sites nightly while they were in use to count individuals emerging. Although not all bats were radio tagged, the switch was assumed to include the entire colony when no individuals were observed emerging from the old colony and the number emerging from the new roost was the same as that emerging from the old roost.

2.3. Sampling scale for roost and habitat characteristics

To characterize the roost site, we measured habitat variables at three different spatial scales: (1) the roost itself, (2) a 0.1 ha (17.8 m radius) circular microplot centered on the roost (hereafter termed roost microplot), and (3) a 78 ha (500 m radius) landscape-level macroplot (hereafter termed roost macroplot). We selected 500 m because it is approximately one-half the longest recorded distance between roosts of individual big brown bats in this study.

To examine whether habitat characteristics of roost sites and randomly selected areas differed, we measured habitat variables at two categories of plots: vicinity and general. The first category was a plot randomly selected in the roost